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DISSOLVED ORGANIC CARBON RELEASE FROM DELTA WETLANDS: AMOUNTS, ALTERATIONS, AND IMPLICATIONS FOR DRINKING WATER QUALITY AND THE DELTA FOODWEB; PART II – FLUXES AND LOADS FROM TIDAL AND NON-TIDAL WETLANDS AND FROM AGRICULTURAL OPERATIONS.

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4.5 PSP Cover Sheet (Attach to the front of each proposal)

Proposal Title: Dissolved Organic Carbon Release from Delta Wetlands: Pt.2
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Amount of funding requested: $ 2,740,040.00 for 3 years

Indicate the Topic for which you are applying (check only one box).

- ☐ Fish Passage/Fish Screens
- ☐ Habitat Restoration
- ☐ Local Watershed Stewardship
- ☒ Water Quality
- ☐ Introduced Species
- ☐ Fish Management/Hatchery
- ☐ Environmental Education

Does the proposal address a specified Focused Action? X yes _____ no

What county or counties is the project located in? Yolo, Solano, Contra Costa, San, Joaquin, Sacramento

Indicate the geographic area of your proposal (check only one box):

- ☐ Sacramento River Mainstem
- ☐ Sacramento Trib: _____
- ☐ San Joaquin River Mainstem
- ☐ San Joaquin Trib: _____
- ☒ Delta: _____
- ☐ East Side Trib: _____
- ☐ Suisun Marsh and Bay
- ☐ North Bay/South Bay: _____
- ☐ Landscape (entire Bay-Delta watershed)
- ☐ Other: _____

Indicate the primary species which the proposal addresses (check all that apply):

- ☐ San Joaquin and East-side Delta tributaries fall-run chinook salmon
- ☐ Winter-run chinook salmon
- ☐ Late-fall run chinook salmon
- ☐ Delta smelt
- ☐ Splittail
- ☐ Green sturgeon
- ☐ Migratory birds
- ☒ Other: Potentially all eco-system organisms
- ☐ Spring-run chinook salmon
- ☐ Fall-run chinook salmon
- ☐ Longfin smelt
- ☐ Steelhead trout
- ☐ Striped bass
- ☐ All chinook species
- ☐ All anadromous salmonids

Specify the ERP strategic objective and target (s) that the project addresses. Include page numbers from January 1999 version of ERP Volume I and II:
ERPP v.1, p 18, EIR/EIS Exec. Sum., p 5, Rev. Wat. Qual. Proj. Plan, p. 15, ERPP, v.2, p 79, ERPP v.2, p 83

Indicate the type of applicant (check only one box):

☐	State agency	☒	Federal agency
☐	Public/Non-profit joint venture	☐	Non-profit
☐	Local government/district	☐	Private party
☐	University	☐	Other: _____

Indicate the type of project (check only one box):

☐	Planning	☐	Implementation
☐	Monitoring	☐	Education
☒	Research		

By signing below, the applicant declares the following:

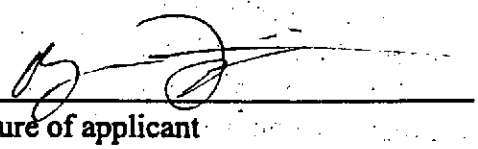
1.) The truthfulness of all representations in their proposal;

2.) The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization); and

3.) The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2.4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

Dr. Roger Fujii

Printed name of applicant



Signature of applicant

Executive Summary

Background:

Rivers, wetlands, and agricultural operations supply organic material to the Sacramento-San Joaquin Delta and San Francisco Estuary, providing essential nutritive material to the food web and thus an important ecosystem benefit. Unfortunately, the presence of high concentrations of organic material in Delta drinking source waters increases the difficulty of treating those waters, and may result in the formation of carcinogenic disinfection byproducts (DBPs) regulated by US EPA.

Over 22 million people drink water from the Delta. It is not known if the creation of new wetlands within the Delta will alter the concentrations of precursors of carcinogenic disinfection by-products (DBPs) that form when Delta water is processed for drinking water. DBPs form when a disinfectant such as chlorine or ozone is added during treatment and then reacts with bromide and naturally occurring DOC.

To restore ecological health in the Bay-Delta system, over 100,000 acres in the Delta may be converted to wetlands. As CALFED proceeds with these ecosystem restoration activities, it is desired that the restored wetlands provide sources of organic material beneficial to the Bay and Delta foodweb while minimizing sources of organic material that would adversely impacting drinking source water quality. An example of how this might be accomplished would be to restore only specific types of wetlands – those exporting small quantities of deleterious organic carbon– on flow paths affecting drinking water intakes.

However, little information is available regarding the amount or quality of organic material released from different types of wetlands (or even agricultural sources) and its effect on either the Delta food web or on drinking water treatment. Consequently, CALFED identified the following 5 questions as the highest priority information needs for assessing the potential effect of ecosystem restorations on dissolved and total organic carbon (DOC, TOC) levels in the Delta:

1. *How much and what forms of TOC do wetlands generate?*
2. *To what extent is TOC released from wetlands altered and consumed in Delta waters?*
3. *By comparison, how much and what forms of TOC are released from agricultural activities?*
4. *What wetland management strategies may be used to limit introduction of TOC into Delta waters?*
5. *How will the impacts of restored wetlands change in the future as they mature?*

Approach:

To answer each of these questions, independent information is needed about both the **quality** and the **amount** of the organic material released from various wetlands and agricultural operations. This proposal addresses questions 1, 3, and 4 relative to **amounts** of organic carbon. A companion proposal addresses all five questions relative to the **quality** of organic carbon released by wetlands and agricultural operations. Different scientific approaches are used to examine these two aspects of DOC release. Together, these proposals will provide a quantitative basis for estimating the relative contributions of different wetlands to Delta TOC/DOC, in comparison to current agricultural activities. When coupled with accurate physical modeling, these results will provide a quantitative basis for estimating the impacts of restoration efforts on organic carbon supply to the Estuary and to drinking water intakes.

The goals of this project are to 1) quantify export loads of DOC and DBPPs from a tidal wetland, a non-tidal wetland, and an agricultural operation; and 2) assess the potential change in contributions of DOC/TOC and DBPPs from changes in land use from agriculture to wetlands.

Study Design:

Only a small fraction of DOC – the disinfection byproducts precursors (DBPPs) – form DBP, and the amount of DBPPs within DOC is highly dependent on the source and extent of degradation of the organic material. Samples from different areas in the Delta have over a 10-fold difference in the amount of DBPPs found within the DOC, on top of the 10-20 fold differences observed in DOC concentration. No studies to date have quantitatively assessed the biogeochemical processes influencing the relative contributions of DOC and DBP precursor sources in the Delta. We propose to quantify the DOC/TOC and DBPP loads from tidal wetlands, non-tidal wetlands, and agricultural operations, and assess their relative importance as sources of carbon for the Delta foodweb and for drinking source water quality.

The companion proposal (Part I) focuses on the concentration and **quality** of DOC/TOC released from different carbon sources to the Delta (wetland types, rivers, and agricultural activities), assessing both DBPPs and the incorporation into Delta foodwebs, and determines how microbial alteration affects the composition of DOC and DBPPs. This proposal (Part II) mainly focuses on the **amounts** (loads) of DOC and DBPPs contributed by tidal and non-tidal wetlands and agricultural operations. Together these two proposals should provide the quantitative and qualitative knowledge needed for CALFED to make informed decisions regarding ecosystem and human health.

A team of scientists with diverse expertise has been assembled to address these issues. Principal investigator Roger Fujii, who will bear responsibility for all scientific products, will lead the team. The various team members bring a wealth of scientific experience in carbon release from peat soils, estuarine transport of sediment and other constituents, physical and chemical processes affecting peat soils, wetland ecology, chemical characterization of natural organic material, organic geochemistry, and the chemistry of DBP formation. The progress and products of the study will be monitored by an independent scientific advisory panel composed of internationally recognized experts in DOC release from wetlands, chemical characterization of DOC, aquatic food web interactions, water treatment, and DBP formation. The final reports will analyze and synthesize the experimental results to identify specific options to CALFED regarding the potential impacts of different restoration actions on drinking source water quality and DOC-supported biological production in the Delta.

Project Description (Maximum3 pages)

Scope of work:

To restore ecological health and improve water quality in the Bay-Delta system, over 100,000 acres in the Delta may be converted to wetlands. This ecosystem restoration will cause a shift in land use away from agriculture to different types of wetlands. Because the organic matter produced and exported to the Delta channels by wetlands is likely to differ markedly from that coming from agricultural lands, this shift in land use will impact both the quality of drinking water and the microbial foodweb. In the water treatment process disinfectants, such as chlorine and ozone, react with naturally occurring organic matter and bromide in the water to produce carcinogenic DBPs. The levels of these DBPs in drinking water are federally regulated and permissible levels are scheduled to become more restrictive over time. Similarly, the nutritional value to the microbial foodweb of organic matter exported from the different wetland types is likely to differ from one another as well as from current land uses. To assess and optimize the benefits of wetland restoration and to manage deleterious impacts, it is necessary to characterize the quantity and quality of organic carbon loading and transformation associated with tidal and non-tidal wetlands and agricultural land use in terms of DBP formation potential and microbial foodweb nutritional value.

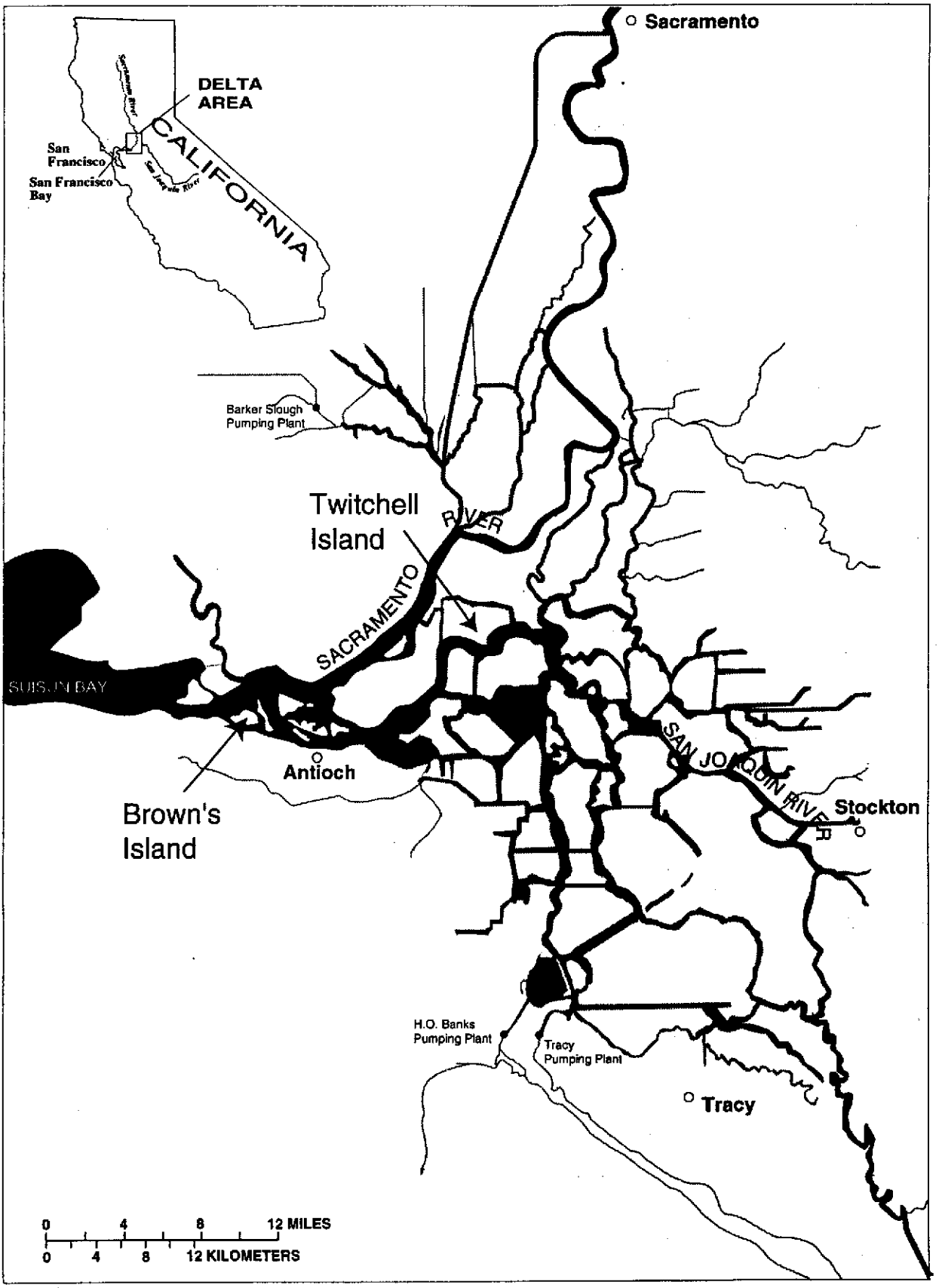
The chemical composition of natural organic matter and the quantity of specific constituents in water determine both the potential for formation of DBPs and the foodweb nutritional value. The companion proposal (Dissolved Organic Carbon Release from Delta Wetlands: Amounts, Alterations, and Implications for Drinking Water Quality and the Delta Foodweb; Part I) to this proposal will examine, in depth, the wetland biogeochemical processes affecting organic matter quality with focus on DOC and links to POC (CALFED POC Study, Cloern).

The goals of this study are to quantitatively assess DOC/TOC and DBPPs loads exported from tidal wetlands, non-tidal wetlands, and agricultural activities into Delta channel waters. This information is currently unavailable and will quantify the relative contributions of DOC as both a food source and DBPP source from wetlands and agricultural activities in a way that will permit direct comparison.

Element I: Tidal wetlands -- Net export loads in tidal systems is extremely difficult to measure and thus expensive to determine. One confounding problem is that the flow is bidirectional – onto and off the wetland. Brown's Island represents a tule marsh having confined exchange with Delta tidal channels. Brown's Island has one major and one minor breach on the same tidal channel. Acoustic velocity meters and Doppler profilers will be used to measure water movement through the breaches. Spectral fluorescence and 9-wavelength absorption/attenuation instruments will be used to measure DOC and DBPPs. An optical backscatterance sensor (OBS) will be used to measure suspended-solids concentration (SSC). Construction of a gagehouse and sampling platforms and acquisition and calibration of optical sensors (task TW1) will occur within 6 months prior to the first deployment (summer of 2000). Instruments deployed will quantify water, solute, and particulate flow on tidally-relevant time scales. Water level, water velocity, SSC, DOC/TOC, and DBPPs will be monitored continuously during 7 seasonal 30-day deployments using calibrated optical sensors over 1.75 years to assess seasonal variability in export loads (task TW2).

Figure 1

Map of proposed study area



In concert with the load studies, measurements of the net accumulation of organic and inorganic material in the surface soil layers will be made at Browns Island (task TW3). Measurements of soil accretion, elevation change, and soil properties will be used to document seasonal changes in the storage of organic material in the marsh soil. The current CALFED Breached Levee Study (Simenstad) has already established one site in the interior section of Browns Island - on a small tributary of the main channel. Here both streamside (e.g., next to the channel) and backmarsh (e.g., approx. 30m in from the channel margin) measurements of elevation change and soil accretion have been made seasonally since March 1998. Higher soil accretion has been measured adjacent to the channel - a pattern common in tidal marshes. In order to characterize the accumulation of material across Browns Island, three new streamside-backmarsh sites will be established and seasonal measurements of soil accretion, soil organic matter content, soil bulk density, and surface elevation change will be made in association with the periods of intensive load measurements.

Element II: Non-tidal wetlands -- A recently restored wetland test site will be used to determine loads of DOC/TOC and DBPPs exported from a non-tidal wetland. This 8-acre wetland test facility differs considerably from tidal wetlands: it is not tidally influenced, continuous standing-water level is maintained at 1.5 ft by water supplied from the San Joaquin River; it was constructed on the interior of subsided Twitchell Island; it is being managed to promote the growth of tules and cattails as biomass sources for mitigating subsidence; and the drainage water is influenced by leaching of organic material from oxidized, decomposed peat soils previously cultivated for several decades. The site is maintained by a separate USGS/DWR study. That study quantifies many of the parameters necessary for determining net carbon export (productivity, decomposition, gaseous carbon flux, and carbon accumulation), thus this proposed study will add the only missing component to comprehensively assess carbon mass balance and cycling for the non-tidal wetland. A previous USGS/DWR study at this site has provided extensive information on DOC concentration and quality for peat soils, surface water, and inflow to and outflow from the wetland. This proposed element will focus on DOC/TOC and DBP precursor (trihalomethanes and haloacetic acids) loads. More detailed DOC characterization and DBP formation potentials will be assessed by the proposed companion study and results from previous studies will guide their efforts.

Our approach uses both mass balance and ground-water modeling to quantify loads of DOC/TOC and DBPPs. The major missing component of carbon export from this system is ground-water seepage to the drainage system. The mass balance approach utilizes water budget measurements (inflow, outflow, surface water, drainage ditch) and associated concentrations of DOC/TOC and DBPPs to calculate the seepage contribution (tasks NTW2 and NTW3). To circumvent difficulties in quantifying loads into the existing drainage ditch, which is common to several fields as well as the non-tidal wetland, a new drainage ditch will be installed along a portion of the system and closely monitored (task NTW1). The only major missing component to the water budget is evapotranspiration (ET), which will be determined using energy-balance and eddy covariance techniques (Snyder et al., 1996) (task NTW4). An added benefit of the ET study will be determination of crop coefficients for use with available reference evapotranspiration (ETo) data to estimate the water use of tules and cattails throughout the Delta. An existing ground-water flow model for this site (developed as part of another USGS/DWR study) will utilize these new data for calibration to assess ground-water seepage to the drainage ditch (task NTW5). Combining the mass balance and

modeling approaches provides a valuable management tool to assess the effects of changing management practices on loads of DOC/TOC and DBPPs generated by non-tidal wetlands.

Agricultural Activities – Agricultural activities comprise approximately 70% of the land use in the Delta. Thus, comparison of quality and quantity of DOC/TOC and quantity of DBPPs generated by irrigated agricultural activities to those generated by wetlands is necessary. Complex and poorly understood interactions of biological, chemical, and physical factors influence the volume and composition of agricultural drainage waters from peat soils. Factors affecting the loading of DOC/TOC and DBPPs to agricultural drainage include the release of organic carbon from the peat and recently deposited plant materials and water movement through the peat. The transport of DOC and DBPPs through saturated peat to drains is represented by the variation in drainage water DOC and DBP precursor loads with time, which is equal to the flux of DOC and DBP precursor through the soil and groundwater plus the release of DOC and DBP precursor from the peat.

A previously studied irrigated corn field on Twitchell Island (Fujii et al., 1998) will be investigated to quantitatively determine DOC/TOC and DBP precursor loads in drainage water, information that has not yet been adequately quantified. Our approach to define the hydrologic effects on volumes of drainage water and loads of DOC/TOC and DBPPs from agricultural land will be to fully understand hydrologic processes and develop a computer model for groundwater and unsaturated flow to drainage ditches in the agricultural field.

Our approach will be iterative. We will begin data collection and develop a preliminary model of the flow system and collect additional data based on the results of the initial modeling effort. The results of initial modeling effort will point to additional data collection needs. The first modeling effort will then be refined based on the additional data collection. Physical data such as groundwater levels, unsaturated-zone pore pressures and hydraulic conductivities will be used to define the saturated and unsaturated flow of water. Chemical data (DOC characterization and THM precursors; Fujii et al., 1998) collected previously by the USGS will be used by this study to minimize analytical characterization of carbon quality. DOC/TOC and DBPs data will be collected during this study and used with the physical data to quantify DOC/TOC and DBP precursor loads in drainage water and the factors affecting the loads. The study will describe the movement of DOC and DBPPs to drainage ditches and predict drainage volumes and loads. Development of the model and in-depth study of a single field will enable us to effectively transfer the results of this study to other locations in the Delta by providing a quantitative framework for understanding the hydrologic processes affecting DOC and DBP precursor loads.

The evaluation will consist of 1) data collection in a single agricultural field on Twitchell Island (tasks AA1 through AA3); 2) the development a model that will describe water movement through the soil and to drainage ditches (task AA4); and 3) evaluation of the relative effects of changing water-management practices on drainage flow and drainwater quality (task AA5). The duration of the project will be 2.5 years. The hydraulic and water quality data will be collected in the field over the course of two years. An additional six months will be used to complete the modeling efforts, analyze different water management scenarios and reporting.

Table of Tasks, Deliverables, and Schedule:

Task	Deliverables	Schedule (completion after start of project)
Element I: Tidal Wetland		
TW1. Gagehouse, sampling platform, sensor acquisition and calibration, etc.	Annual Progress Report	9 months
TW2. Deployment of instruments and determination of water, DOC/TOC and DBPP loads	Annual Progress Reports	28 months
TW3. Accretion of organic and inorganic material	Annual Progress Reports	28 months
TW4. Reporting	Annual Progress Reports, Final report	36 months
TW5. Management	Annual Progress Reports	36 months
Element II: Non-Tidal Wetland		
NTW1. Installation of drainage ditch and instrumentation	Annual Progress Report	6 months
NTW2. Water budget assessment	Annual Progress Reports	30 months
NTW3. DOC/TOC and DBPP load assessment	Annual Progress Reports	30 months
NTW4. Evapotranspiration assessment	Annual Progress Reports	30 months
NTW5. Ground-water modeling	Annual Progress Reports	30 months
NTW6. Reporting	Annual Progress Reports, Final report	36 months
NTW7. Management	Annual Progress Reports	36 months
Element III: Agricultural Activities		
AA1. Field instrumentation and site preparation	Annual Progress Report	3 months
AA2. Water quality sampling	Annual Progress Reports	24 months
AA3. Hydraulic data collection	Annual Progress Reports	24 months
AA4. Loads assessment and model development, calibration, and sensitivity analysis	Annual Progress Reports	28 months
AA5. Simulation of water-management scenarios	Annual Progress Reports	29 months
AA6. Reporting	Annual Progress Reports, Final report	30 months
AA7. Management	Annual Progress Reports	30 months

Location and/or Geographic Boundaries of the Project: The tidal wetland site (Brown's Island) is located in Solano county and the non-tidal wetland site and the agricultural site are located on Twitchell Island in Sacramento County (figure 1.)

Ecological/ Biological Benefits

Ecological/Biological Objectives

Primary Objectives:

I. Determine the net export loads of DOC/TOC and DBPPs from tidal wetlands.
II. Determine the loads of DOC/TOC and DBPPs generated by non-tidal wetlands.
III. Determine the loads of DOC/TOC and DBPPs generated by agricultural operations.
IV. Develop a quantitative model to assess the potential changes in contributions of DOC/TOC and DBPP concentrations from changes in land use from agriculture to wetlands.

This project provides substantial ecological benefit by determining the loads of DOC/POC and DBPPs generated by a tidal wetland (tule marsh), a non-tidal wetland (tule, cattail), and an agricultural operation. At this time, the relative potentials of these important contrasting land uses to export DOC and DBPP are unknown. The quantitative information about fluxes and loads to be generated by this project are critical for addressing the fundamental question of potential impacts of wetland restoration in the Delta on both ecosystem food source (DOC/POC) and drinking-water quality (DBPP) relative to agricultural. These results should help define potential positive and negative ecosystem and public health effects of proposed CALFED restoration activities that can be used by resource managers in their decision making process.

There are potentially significant quantitative and qualitative differences in the organic material supplied from each of these system. Organic matter, whether it is dissolved or particulate, provides the fuel for Delta foodwebs. Organic material from tidal wetlands is influenced by wetland vegetation (biomass, detritus, plant exudates) and deposition and transport of organic material associated with suspended sediments (including phytoplankton and zooplankton). In contrast, non-tidal wetlands and agricultural operations in the Delta are influenced by organic material associated wetland vegetation and residue from crops, respectively, and leaching of organic matter from peat soils. The type of DOC generated by some non-tidal wetlands has been shown to be four to five fold more reactive in the formation of THMs relative to the DOC produced by agricultural operations (Fujii et al., 1998). Restoration of tidal and non-tidal wetlands in the Delta and replacement of agricultural lands with wetlands is likely to change the concentration and quality of organic matter in Delta channel waters, thereby impacting both carbon quantity and quality as an ecological food source and as a DBPPs source to drinking water.

Questions/Hypotheses to be evaluated (more detail provided in the monitoring and methods table):

1. How do DOC/TOC and DBPP export loads from tidal wetlands, non-tidal wetlands, and agricultural operations differ in both quantity and quality? (Elements I, II, III)
2. What are the seasonal variations in DOC/TOC and DBPP export loads from tidal wetlands? (Element I)

3. How significant is sediment transport (POC) relative to DOC in organic matter exchange for a tidal wetland? (Element I)
4. How much of the organic matter produced in a mature tidal wetland is exported as POC/DOC vs. that amount held in long-term storage in the marsh soil (ie., peat development)? (Element I)
5. What are the crop coefficients for evapotranspiration for tules and cattails? (Element II)
6. How does leaching of peat soils and subsurface flow affect the loads of DOC/TOC and DBPPs in drainage water for an agricultural field? (Element III)
7. How are these loads affected by agricultural management practices? (Element III)
8. What are the effects of varying agricultural water-management practices on drainage volumes and DOC/TOC and DBPPs loads in drainage water? (Element III)

Linkages

This project addresses several CALFED ecosystem and water-quality goals. In terms of drinking-water quality, it addresses water quality concerns at their source (ERPP v. 1, p. 18) and examines potential significant redirected impacts (EIR/EIS Exec. Sum., p. 5) wetland restoration may have on drinking-water utilities. It also addresses identified source and load information needs for drinking water parameters of concern (Rev. Wat. Qual. Proj. Plan., p. 15). In terms of Delta foodweb issues, this proposal quantitatively examines producitvity enhancements through wetland restoration (ERPP v. 1, p. 98) and improvements to the Bay-Delta Aquatic Foodweb (ERPP, v. 2, p. 79), and specifically addresses the microbial component of the Delta Foodweb Organisms (ERPP v. 2, p. 83).

This project complements the ongoing CALFED-funded study of POC in the Bay/Delta by USGS scientists and collaborators, and integrates with that study (samples from the three sites proposed here will be shared), as well as the CALFED-funded study of restorations of different ages (Breached Levee Study) by Charles Simenstad and others on the Wetland Ecosystem Team. Brown's Island is one of the Breached Levee Study sites and we will make use of all historical data, and all ongoing data collection will be coordinated (Element I).

The non-tidal wetland and agricultural study sites (Elements II, III) identified for this project are the same sites used in previous USGS/DWR studies on agricultural TOC and wetlands by USGS scientists and collaborators. The two sites are located adjacent to each other on the same soil type so that comparison of results will reflect mainly land use. Existing instrumentation and facilities will be used whenever possible to decrease study costs. DOC characterization results from previous studies also will be used to minimize these costly in-depth analyses and to guide the sampling and analytical design. In addition, the non-tidal wetland site currently is used in an ongoing USGS/DWR study (Fujii and Hastings/Schmutte) to assess the use of wetlands to mitigate subsidence in the Delta. Existing facilities and new data for this site will be used for the proposed study and data will be shared wherever possible to minimize costs.

Another CALFED-funded project (A Learning Laboratory for Restoring Subsided Lands in the Delta, Demonstration of Techniques for Reversing Subsidence in the Sacramento-San Joaquin Delta) scheduled to begin in May 1999 will complement the non-tidal wetland study (ElementII) proposed. The proposed study will examine DOC/TOC and DBPPs loads generated by a non-tidal wetland that has extensive coverage by wetland plants (tules and cattails) and will therefore account for the impact of wetland vegetation (biomass

decomposition, plant exudates, and detritus). In contrast, the funded CALFED project focuses on a newly restored non-tidal wetland where wetland vegetation growth will be minimal. Comparison of these two systems will provide complementary knowledge of the effects of restored non-tidal wetlands on DOC/TOC and DBPPs loads, the proposed study focusing on a more mature wetland and the already funded project on a newly restored wetland. Also, the funded CALFED project does not explicitly assess evapotranspiration of wetland plants but will make use of the results of this assessment from the proposed study.

The agricultural field site (Element III) is also the site for a study (DOC Production from Cultivated, Organic Soils on Twitchell Island, Sacramento-San Joaquin Delta) being conducted by Professor K.K. Tanji (University of California, Davis) that is funded (1998, 1999) by the Centers for Water and Wildland Resources. The study examines DOC release from peat soils and relates DOC quality to potential formation of THMs. Two of the investigators for this proposed study (Fujii and Bergamaschi) are advisors to the UC Davis study. Results from the study will be incorporated into the agricultural operations assessment.

This study also is tied to the study proposed by DWR MWQI program in which they will be simulating land uses (e.g., agricultural, wetland), similar to those proposed in this study, using short-term mesocosm experiments. These two approaches are complementary and data and results will be shared between the two projects where possible.

Compatibility with Non-Ecosystem Objectives

The project provides benefits for the CALFED drinking-water quality objective as well as for the ecosystem health objective. The project will provide data for comparing loads of DBPPs from tidal and non-tidal wetlands and for agricultural operations. These data are the necessary for determining potential adverse effects of ecosystem restoration on municipal water users (potential third-party benefits).

Technical Feasibility and Timing

A survey of potential tidally influenced, restored wetland sites in consultation with Jim Cloern (USGS, CALFED POC Study) and Charles Simenstad (University of Washington, CALFED Breached Levee Study) did not identify a tidally influenced, restored site that was economically or logistically feasible for this project. For this reason, we have chosen Brown's Island as our tidal-wetland site. Brown's Island represents a tidal wetland dominated by tules and cattails and other sedges. In our opinion, a site containing relatively mature wetland vegetation (Brown's Island) is desirable over a newly formed wetland because influences of biomass accretion, decomposition, plant exudates, and other factors on DOC/TOC quality, as related to DBPPs and the foodweb, are expected to be significant and will be accounted for at Brown's Island. In addition, such a mature sites represents an expected end-point of tidal marsh restoration efforts in the Delta and assessment of organic loads from such a system allows projection of the long-term effects of such restoration on water quality.

There are no CEQA, NEPA or other environmental compliance documents required for this proposal. There are no outstanding implementation issues (other than funding). Permission to use sites on Twitchell Island has been given by DWR, memos of documentation will be obtained.

Monitoring and Data Collection Methodology

Biological/ecological objectives: Please see page 9.

***Monitoring parameters and data collection approach*:** Please see methods table below.

Data evaluation approach

A Scientific Advisory Panel will review the work plan and interpretative reports generated by the study to ensure the highest standards of scientific quality and integrity. Scientists representing a wide range of expertise have agreed to serve in this advisory capacity:

Prof. Gary Amy (U. Co.), an internationally recognized expert on DBP formation in drinking water treatment. Dr. Amy recently served on the CALFED Bromide expert panel.

Dr. George Aiken (USGS Boulder), with more than 20 years experience analyzing DOC from throughout the world using ^{13}C-CPMAS NMR.

Dr. Ronald Benner (U. Texas), who provides expertise on compositional characteristics of DOC released from wetlands and the utilization of DOC by microbial communities.

Dr. Bryan Fry (U. La.), an expert at application of isotopic techniques to foodweb studies.

Dr. James Cloern (USGS Menlo Park), internationally recognized for contributions on foodweb carbon dynamics. Dr. Cloern also provides an important interpretive link to the existing CALFED-funded study on POC.

Dr. S. Geoffrey Schlader (UC Davis) is an expert on constituent transport in estuarine and reverine environments.

Dr. Charles Simenstad (U. Washington), Director of the Wetlands Ecosystems Team, is currently engaged in a CALFED funded study on wetlands formed following levy breaches, and provides expertise on wetland habitats.

Dr. K.K. Tanji (UC Davis) is an internationally recognized expert on irrigated agricultural systems and has had extensive experience working with peat soils in the Delta.

Douglas M. Owen, P.E. (Malcolm-Pirnie, Inc.), an expert consultant on the role of natural organic matter in the formation of DBP, and removal in the water treatment process.

Table 2. Monitoring and Data Collection Information

I. Determine net export loads of DOC/TOC and DBPP for tidal wetlands.		
Hypothesis/Question to be Evaluated	**Monitoring Parameters and Data Collection Approach**	**Data Evaluation Approach and comments**
What is the net particulate organic carbon load onto or out of the wetland?	Seven month-long seasonal deployments to capture spring-neap variability, seasonal variability, and interannual variability. Optical backscatter sensors sampling at 15 minute intervals combined with acoustic velocity meters will be used to determine particulate flux on tidal time-scales[1]. Sensors will be intensively calibrated by comparison to discrete samples analyzed for particulate concentration and organic carbon content[2].	Net loads will be determined by examining the residual flows from low-pass filtered data.
What is the net DOC load onto or out of the wetland?	Deployments as above. DOC concentrations will be determined using in-situ 9 channel UV absorbance sensors sampling at 15 minute intervals[3]. Calibrations for each channel will be determined on site by measuring the DOC in discrete samples[4]. Multi-wavelength calibration increases the accuracy of the determination. Periodic samples will be collected during the deployment to ensure calibrations do not change.	As above
What is the net DBPP load onto or out of the wetland?	Since the composition of the organic material flowing onto and off tidal wetlands is likely to change between seasons, a continuous, multi-channel, on-line fluorescence sensor will be used to estimate carbon quality[5]. Calibrations of DBP formation[6] and fluorescent wavelength optimization will be performed as part of the companion study. Calibration samples for this study will be collected as part of the calibration set described above. Sensors will collect data every 15 minutes. Multi-wavelength calibration increases the accuracy of the determination.	As above
Is the wetland accumulating or losing organic carbon on a net basis?	Marsh surface elevation change will be measured using several benchmark sites within the wetland (SET)[7]. Marsh accretion and soil properties will be measured seasonally by direct sampling[8].	Seasonal sampling and annual evaluation of data to document net accumulation. Accumulation compared to flux measures annually.
Does the export of carbon from the wetlands into Delta channels change on a seasonal basis?		Statistically compare seasonally averaged data from previous study elements.
What is the net export benefit to the Delta foodweb from this tidal wetland?	Use load data from this study along with carbon quality data from the companion study to estimate net foodweb benefit.	Compile load and quality/lability information, estimating error in natural variability. Estimate error in final determination using statistical techniques.
II. Determine the loads of DOC/TOC and DBPP generated by non-tidal wetlands.		

Hypothesis/Question to be Evaluated	Monitoring Parameters and Data Collection Approach	Data Evaluation Approach and comments
What is the net particulate organic carbon load out of the wetland?	Wetland will be studied intensively for 16 one week periods over two years to cover interannual variability. Particulate content in the outflow will be continuously monitored using an OBS sensor[1]. Outflow volumes will be measured by another study. Samples will be collected by autosampler every 2 hours for calibration and POC determination[2].	Net fluxes will be determined by mass balance.
What is the net DOC load out of the wetland?	Samples will be collected by autosampler every 6 hours during the intensive study periods for DOC determination[4].	As above
What is the net DBPP load out of the wetland?	Samples will be collected by autosampler every 6 hours during the intensive study periods for DBP determination[6] or estimation of DBP formation using optical techniques[5].	As above
What are the crop coefficients for evapotranspiration for tules and cattails?	Estimate evapotranspiration using surface renewal and eddy covariance techniques[9]. Crop coefficients determined using these data and data from DWR CIMIS station on Twitchell Island.	Statistical analysis of eddy correlation data.
III. Determine the loads of DOC/TOC and DBPP generated by agricultural operations.		
Hypothesis/Question to be Evaluated	**Monitoring Parameters and Data Collection Approach**	**Data Evaluation Approach and comments**
How does leaching and subsurface flow affect the DOC/TOC and DBPP composition of the drainage waters?	Monitoring of drain, groundwater and soil water quality[10], drainflow, measurement of water potential, soil and groundwater hydraulic parameters, and measurement of DOC/TOC[4] and DBPP[6] throughout monitoring period.	Statistical and modeling
What are the effects of varying water-management practices on the drainage volumes and the DOC and DBP loads in drainage water?	Collection of physical and chemical data[10] for varying water-management practices.	As above
How do DOC and DBP loads from agricultural lands compare with wetland areas?	Comparison of water quality and drain loads for tidal and non-tidal wetland sites and agricultural fields.	As above.
IV. Develop a quantitative model to assess the potential changes in contributions of DOC/TOC and DBPP concentrations from changes in land use from agriculture to wetlands.		
Hypothesis/Question to be Evaluated	**Monitoring Parameters and Data Collection Approach**	**Data Evaluation Approach and comments**
Will changes in land use in the Delta alter the	Use data from companion proposal in conjunction with export load data determined from study	Model will be useful for evaluating net effects of

net export of organic carbon?	elements described above to formulate a model affect of landscape features on DOC, POC and DBPP concentrations. Model parameters will include wetland channel exchange volume, wetland type, agricultural crop, soil type, agricultural water use, season, and others.	prospective land-use change. It will not be useful for determining changes at any specific location until it is incorporated into a physically realistic flow model of the Delta.
Will changes in carbon export provide a net ecosystem benefit?	Use model described above to evaluate the changes in export of labile organic material, beneficial to the Delta foodweb and Estuary foodweb.	As above.
Will changes in carbon export provide a net change in the propensity of Delta waters to form DBPs when treated for use as drinking water?	Use model described above to evaluate the changes in export of DBP precursors.	As above.

[1]Optical backscatter sensors (OBS) are deployed and operated following the method of Buchanan and Schoellhamer (1998). OBS operates by emitting pulses of infrared light into the water column and measuring the amount of light reflected back to the sensor by the particles suspended in the water column. The measured voltage of reflected light is proportional to the suspended particle concentration in the parcel of water 0.5 to 30 cm in front of the sensor.

[2]Particulate organic carbon concentrations are determined by filtering a known volume of water through a 0.45 μm filter, measuring the mass of the solid material extracter, then measuring the carbon content of the solid material using a Perkin-Elmer 2400 II CHNS/O Elemental Analyzer (@@)

[3]Ultraviolet absorption is measured at nine wavelengths using a WetLab instrument deployed at the field site and equipped with an ultraviolet sensor (Standard Method 5910). Organic structures in the DOC absorb UV light at characteristic wavelengths and absorbance is proportional to concentrations. DOC concentration is calculated using intensity data from all nine wavelengths in order to account for compositional variations in the DOC which will affect UV absorbance at individual wavelengths.

[4]Dissolved organic carbon (DOC) and total organic carbon (TOC) concentrations are measured on filtered and unfiltered samples, respectively, with a Shimadzu TOC 5000A analyzer (Standard Methods 5310B).

[5]Fluorescence is measured at twelve excitation-emission wavelength pairs using a WetLab instrument deployed at the field site and equipped with a fluorescence sensor. Some organic structures in DOC fluoresce (emit light) at characteristic wavelengths when excited by incident light of characteristic wavelengths. Many fluorophors contain structures, such as aromatic rings or unsaturated structures with carbonyl groups, that are also very common in DBP precursor compounds. The twelve channels will be chosen based on the results of full-scan excitation-emission fluorescence spectra acquired on samples collected for the companion proposal.

[6]Disinfection byproduct precursor (DBPP) contents are measured by determining trihalomethane and haloacetic acid formation potentials (THMFP and HAAFP) on discrete water samples collected at the sensor. THMFP are measured following the method of Krasner and Sclimenti (1993), and HAAFP are measured following US EPA method 552.2.

[7]Sediment-erosion table (SET) measurements are made following the method of Boumans and Day (1993). SET measures small changes in sediment surface elevation (plus or minus) relative to a benchmark elevation established by driving a metal pipe into the soil to refusal.

[8]Direct measurements of marsh accretion are made by installing a white feldspar marker horizon at the beginning of the study and then measuring the thickness of soil accreted on the marker horizon over time by cryogenic coring following the method of Cahoon et al. (1996). Cryogenic coring eliminates the compaction and disturbance of the soil associated with conventional coring and the thickness of soil ontop of the marker horizen can be measured directly on the extracted mini-core. Larger bore, conventional coring is used to collect soil samples which are then visually examined, analyzed with the elemental analyzer (method 2) for C, N, H contents, and dried and ashed to determined water and ash contents.

[9]Surface renewal and eddy covarience estimations of evapotranspiration are made following the methods of Snyder et al (1996, 1997). These data, combined with data from the nearby California Department of Water Resources California Irrigation Management Information System (CIMIS) station are used to calculate crop coefficients (UC Cooperative Extension Leaflet 21427)

[10]Soil water quality parameters are measured following the methods of Fujii et al (1998) and USGS (1980).

Local involvement

Effects of ecosystem restoration on carbon quality and quantity and the potential impacts of these changes on both the Delta foodweb and drinking source water quality are serious concerns of urban water users and those concerned with the health of the Delta ecosystem. Attached are letters of support from ...

Costs

Table 3. Total Budget (CALFED funds only): Please see Table of Tasks, p.8, for task descriptions.

Task	Direct Labor Hours	Direct Salary and Benefits	Service contracts	Material and Acquisition Costs	Miscellaneous Direct Costs (travel, tuition, publication costs)	Overhead and Indirect Costs	**Total Cost**
Element I: Tidal Wetland							
TW1	1200	47056	0	0	150996	183137	**381188**
TW2	4288	155215	0	0	26824	174083	**356122**
TW3	672	29421	0	0	16950	12056	**58427**
TW4	6040	246573	0	0	32076	266122	**544771**
TW5	1440	56731	0	0	2105	55895	**114731**
Total by category	13640	534995	0	0	228951	691293	**1,455238**
Element II: Non-tidal Wetland							
NTW1	280	5608	0	0	16985	21464	**44058**
NTW2	2048	31704	0	0	6842	36619	**75164**
NTW3	5184	76382	0	0	23895	95263	**195540**
NTW4	1600	23744	0	0	34923	7816	**66483**
NTW5	1000	26750	0	0	1579	26913	**55242**
NTW6	5408	82400	0	0	11053	88780	**182232**
NTW7	520	17292	0	0	13032	25927	**56251**
Total by category	16040	263880	0	0	108309	302781	**674971**
Element III: Agricultural Activities							
AA1	305	20800	15000	47500	9500	7500	**100000**
AA2	1940	85384	51000	30500	19026	63364	**249275**
AA3	480	24000	0	1500	0	12000	**37500**
AA4	1025	65625	0	0	11250	28125	**105000**
AA5	150	8500	0	0	2000	4500	**15000**
AA6	730	37250	0	0	3000	18250	**58500**
AA7	200	12000	0	0	24556	8000	**44556**
Total by category	4830	253559	66000	79500	69032	141739	**609831**
GRAND TOTAL by category	34510	1052434	66000	79500	406292	1135813	**2740040**

Table 4. Quarterly Budgets (CALFED funds only): Please see Table of Tasks, p.8, for task descriptions.

TASK	Oct-Dec 99	Jan-Mar 00	Apr-Jun 00	Jul-Sep 00	Oct-Dec 00	Jan-Mar 01	Apr-Jun 01	Jul-Sep 01	Oct-Dec 01	Jan-Mar 02	Apr-Jun 02	Jul-Sep 02	Total Budget
TW1	127000	127000	127000										381000
TW2				50875	50875	50875	50875	50875	50875	50875			356122
TW3				4385	5847	8770	10232	7298	8758	7298	5839		58427
TW4				204289				204289				136192	544771
TW5	9561	9561	9561	9561	9561	9561	9561	9561	9561	9561	9561	9561	114731
NTW1	22029	22029											44058
NTW2	7516	7516	7516	7516	7516	7516	7516	7516	7516	7516			75164
NTW3	19554	19554	19554	19554	19554	19554	19554	19554	19554	19554			195540
NTW4	6648	6648	6648	6648	6648	6648	6648	6648	6648	6648			66483
NTW5	5524	5524	5524	5524	5524	5524	5524	5524	5524	5524			55242
NTW6				68337				68337				45558	182232
NTW7	4688	4688	4688	4688	4688	4688	4688	4688	4688	4688	4688	4688	56251
AA1	45000	20000	20000	10000	5000								100000
AA2	30000	27409	27409	27409	27409	27409	27409	27409	27409				249275
AA3	7500	4000	4000	4000	4000	4000	4000	4000	2000				37500
AA4		30000				25000	25000	25000					105000
AA5									10000	5000			15000
AA6			8500		8500		8500		20000	13000			58500
AA7	4456	4456	4456	4456	4456	4456	4456	4456	4456	4456			44556

Overhead and other Indirect Costs for the USGS: Indirect costs of the U.S. Geological Survey (USGS) are a combination of National (WOTSC) and District (DOTSC) costs. Each percentage rate is determined at its appropriate level - simplistically, the WOTSC percentage is based on Headquarters and Regional Office expenditures divided by the entire anticipated USGS funding, the DOTSC percentage is based on each District's common services expenditures divided by the District's anticipated funding. These percentages are then applied separately to the net expenses of a proposal.

WOTSC consists of labor and non-labor expenses for Headquarters and Regional Office staffs, along with general expenses such as (but not limited to) rent, communications and database management. DOTSC consists of labor and non-labor expenses at the District level for Management and Services Support staffs (technical, administrative, computer, database management and general reports), and general District expenses such as (but not limited to) rent, communications and database management.

Justification for other entities are attached.

Schedule

Products and schedule:

Products and schedules for completion of tasks can be found in the Table of Tasks, Deliverables, and Schedules, page 8. Annual Progress Reports will present findings, mainly data results, in relation to the ecological and biological objectives. We will convene annual conferences for CALFED and other interested parties and stakeholders at which results and

progress will be presented. It is anticipated that some results also will be published as USGS reports and in peer-reviewed journals.

This proposal is comprised of three elements (tidal wetland, non-tidal wetland, and agricultural operations) which are linked to the companion proposal (Part I). Incremental funding for each of these elements would reduce the comparability of the data to the companion study and other elements of this study due to interannual differences in climate and flows. Results from the companion study are necessary to determine the detailed organic matter characterizations and analyses to assess the nutritive value of the loads of DOC/TOC to the Delta foodweb and the comprehensive DBPP load impacts. Also, logistical coordination with existing projects would be lost by delaying either tasks II or III and thus incur further costs. In addition, delays in funding of any element of this proposal also would uncouple it from other linked studies as described in the ***Linkages*** section (p. 10, 11). Nevertheless, it is feasible to stage these activities to fund sequentially over the next 3 years if necessary without significant compromise to the scientific objectives.

Cost Sharing

This proposed study will be integrated with two ongoing studies: the CALFED Category III POC Study (USGS, Cloern) and the USGS/DWR funded study (Fujii and Hastings/Schmutte) of Subsidence Mitigation. The POC study is a jointly-funded three-year project between USGS ($0.8M) and CALFED ($1.4M) and the Subsidence Mitigation study is a jointly-funded ongoing project between the USGS ($275,000/yr) and DWR ($395,000).

At this time, USGS Federal Matching Funds (FMF) for Federal FY2000 are not available. However, if FMF become available in FY2001 and/or FY2002 for this study, CALFED will be informed as soon as possible.

Applicant Qualifications:

Roger Fujii received his Ph.D. in soil chemistry from the University of Wisconsin, Madison, in 1983. He has conducted applied geochemical research for the USGS since 1984 and is currently the Project Chief for the USGS Drinking Water Initiative study of the Sacramento-San Joaquin River Delta, which focuses on drinking water quality issues related to DOC and DBPs. He is senior author of a recently published report entitled "Dissolved Organic Carbon Concentrations and Composition, and Trihalomethane Formation Potentials in Waters from Agricultural Peat Soils, Sacramento-San Joaquin Delta, California: Implications for Drinking-Water Quality" (USGS Water Resources Investigations Report 98-4147).

Bergamaschi, B.A., Fram, M.S., Kendall, C., Silva, S.R., Aiken, G.R., and Fujii, R (1999) Carbon isotopic constraints on the contribution of plant material to the natural precursors of trihalomethanes. In press. Organic Geochemistry.

Fram, M.S., Bergamaschi, B.A., Kendall, C., Silva, S.R., Aiken, G.R., and Fujii, R (1998) Changes in the carbon isotopic composition of trihalomethane formed during progressinve chlorination of dissolved humic material. Amer. Chem. Soc., Div. Environ. Chem., Preprints Extd. Absts., v. 38, p. 52-53.

Brian Bergamaschi received a Ph.D. in Chemical Oceanography from the University of Washington, in Seattle, WA. He specialized in analyzing the sources and fates of natural organic material in the environment, for which he received an award for an outstanding dissertation in Chemical Oceanography (ONR/NSF). For the past 4 years, he has been with the USGS investigating the activity of natural organic material in the environment focusing on

the Sacramento-San Joaquin Delta. Recently, he has been focusing on the sources of DBPPs in surface waters.

Bergamaschi, B.A., Fram, M.S., Kendall, C., Silva, S.R., Aiken, G.R., and Fujii, R (1999) Carbon isotopic constraints on the contribution of plant material to the natural precursors of trihalomethanes. In press. Organic Geochemistry.

Bergamaschi B. A., Baston D. S., Crepeau K. L., and Kuivila K. M. (1999) Determination of pesticides associated with suspended sediments in the San Joaquin River, California, U.S. A., using gas chromatography-ion trap mass spectrometry. In Press. Toxicological and Environmental Chemistry.

Bergamaschi B. A., Walters J. S., and Hedges J. I. (1999) Distributions of uronic acids and *O*-methyl sugars in sinking and sedimentary particles in two coastal marine environments. In Press. Geochimica et Cosmochimica Acta.

Steven Deverel, Ph.D. (HydroFocus, Inc.) is a consulting hydrologist with over 17 years experience in the Delta. As a doctoral candidate at UC Davis, he evaluated the chemical and physical processes affecting soil and ground water quality in the Delta. Dr. Deverel worked as a Research Chemist at the US Geological Survey from 1984 to 1991 where he evaluated the gaseous and aqueous carbon fluxes associated with subsidence of peat soils used for Delta agriculture. This work was published in. Dr. Deverel has also has extensive experience in quantifying the processes affecting water quality of agricultural drainage water. An examples of this work is described in

Deverel, S.J., Rojstazcer, S.A. 1996, Subsidence of agricultural lands in the Sacramento-San Joaquin Delta, California: Role of aqueous and gaseous carbon fluxes, Water Resources Research, 32, 2359-2367

Deverel, S.J. and Fio, J.L., 1991, Groundwater flow and solute movement to drain laterals, western San Joaquin Valley, California. I. Geochemical assessment and II. Quantitative hydrologic assessment, Water Resources Research, 27, 2233 - 2257.

David Schoellhamer received a Ph.D in Coastal and Oceanographic Engineering from the University of Florida in 1993. From 1987 to 1993 he conducted a study of sediment resuspension in Tampa Bay, Florida, for the USGS. Since 1993 he has studied sediment transport in San Francisco Bay and Delta, including suspended-sediment flux at several locations in the Bay and Delta and recently in the Napa/Sonoma Marsh Complex. He and Randal Dinehart are studying sedimentation in the Delta and Suisun Bay for CALFED.

Oltmann, R.N., Schoellhamer, D.H., and Dinehart, R.L., 1999, Sediment inflow to the Sacramento-San Joaquin Delta and the San Francisco Bay: Interagency Ecological Program newsletter, v. 12, no. 1, pp. 30-33.

Schoellhamer, D.H., 1996, Factors affecting suspended-solids concentrations in South San Francisco Bay, California: Journal of Geophysical Research, v. 101, no. C5, p. 12087-12095.

Warner, J.C., Schoellhamer, D.H., and Burau, J.R., 1997, A sediment transport pathway in the back of a nearly semienclosed subembayment of San Francisco Bay, California: Proceedings of the XXVII International Association of Hydraulic Research Congress, August 10-15, 1997, San Francisco, California, v. 2, p. 1096-1101.

Miranda Fram received her Ph.D. in Geological Sciences from Columbia University and the Lamont-Doherty Earth Observatory in New York, and was then awarded a University of California President's Postdoctoral Fellowship at UC Davis. For the last 1 ½ years she has been with the USGS working on a variety of projects concerning organic carbon composition and DBP formation, primarily in Delta waters, and developing methods for analyzing trihalomethane formation potentials, and the carbon isotopic composition of trihalomethanes. Recent publications include:

Fram, M.S., Bergamaschi, B.A., Kendall, C., Silva, S.R., Aiken, G.R., and Fujii, R (1998) Changes in the carbon isotopic composition of trihalomethane formed during progressinve chlorination of dissolved humic material. Amer. Chem. Soc., Div. Environ. Chem., Preprints Extd. Absts., v. 38, p. 52-53.

Fram, M.S. and Lesher, C.E. (1997) Generation and polybaric differentiation of East Greenland Early Tertiary flood basalts. Journal of Petrology, v. 38, p. 231-275.

Denise Reed received her PhD in coastal geomorphology, University of Cambridge, 1986, where she examined sediment transport in tidal salt marshes and since 1986 she has worked on coastal marsh studies in the United States. Her work has focused in Louisiana on the

effects of levees and structures on tidal sedimentation processes where she was an Associate Professor at LUMCON until 1998. Dr. Reed has also received funding from NOAA, USGS and CALFED for work on marsh accretion and elevation change on the Atlantic and Pacific coasts of the US, and is presently an Associate Professor, University of New Orleans.

Reed, D.J. 1995. The response of coastal marshes to sea-level rise: survival or submergence?. *Earth Surface Processes and Landforms*, 20, 39-48.

Cahoon, D.R., D.J. Reed and J.W. Day. 1995. Estimating shallow subsidence in microtidal salt marshes of the southeastern United States: Kaye and Barghoorn revisited. *Marine Geology* 128: 1-9.

Reed, D.J., N. De Luca and A.L. Foote. 1997. Effect of hydrologic management on marsh surface sediment deposition in coastal Louisiana. *Estuaries* 20: 301-311.

Richard L. Snyder received a Ph.D. in Agricultural Climatology from Iowa State University, in Ames, Iowa, where he specialized in biometeorology and plant water relationships. He is currently at the University of California, Davis, as the Extension Biometeorologist. His research emphasis is measuring evapotranspiration, improving irrigation scheduling, and frost protection of crops. He was the principle investigator for the California Irrigation Management Information System (CIMIS) project, which supplies evapotranspiration information statewide. More recently, he has worked extensively on the development of the surface renewal and eddy covariance methods to measure evapotranspiration in situ.

Snyder, R.L., D. Spano, and K.T. Paw U. 1996. Surface renewal analysis for sensible and latent heat flux density. Boundary Layer Meteorol. 77: 249-266.

Snyder, R.L., P.W. Brown, K.G. Hubbard, and S.J. Meyer. 1996. A guide to automated weather station networks in North America (*In*) Advances in Climatology Vol. 4. G.Stanhill (Ed.) Springer Verlag, Berlin. p. 1-61.

Snyder, R.L., K.T. Paw U, D. Spano, and P. Duce. 1997. Surface renewal estimates of evapotranspiration - Theory. Acta Horticulturae

Emmanual Boss received his Ph.D. in Physical Oceanography from the University of Washington in 1996 researching the dynamics of unstable currents and the behavior of particles and dissolved tracers. He has had extensive experience using continuous optical measurements of colored dissolved organic (CDOM) and particulate matter (absorption and fluorescence) to provide estimates of key biological and chemical parameters and evidence for a CDOM source from the bottom during sediment resuspension.

Boss, E. and L. Thompson. 1999. Lagrangian and tracer dynamics in the vicinity of an unstable jet. Journal of Physical Oceanography, 29, 288-303.

Boss, E., W. S. Pegau, J. R. V. Zaneveld and A. H. B. Barnard. 1998. Spatial and temporal variability of absorption by dissolved material at a continental shelf. Journal of Geophysical Research, submitted.

Karp-Boss, L., Boss, E. and P. Jumars. 1996. Nutrient fluxes to planktonic osmotrophs in the presence of fluid motion. Oceanography and Marine Biology, An Annual Review., 34, 71-107.

STATE OF CALIFORNIA

NONDISCRIMINATION COMPLIANCE STATEMENT

STD. 19 (REV. 3-95) FMC

COMPANY NAME: HydroFocus, Inc.

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME: Steven John Deverel

DATE EXECUTED: 4-13-99

EXECUTED IN THE COUNTY OF: Yolo

PROSPECTIVE CONTRACTOR'S SIGNATURE: S. Deverel

PROSPECTIVE CONTRACTOR'S TITLE: President

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME: HydroFocus, Inc.

I-019352

Department of Geology and Geophysics
University of New Orleans

1065 Geology & Psychology Bldg. - New Orleans, LA 70148-2850
(504) 280-6325 - Fax: (504) 280-7396

To: Roger Fujii
From: Denise Reed
Date: 14 April 1999
Re: UNO Indirect Cost rate Agreement

Herewith is a copy of our agreement that shows 26% as the Off campus rate for our Indirect costs.

Please call or e-mail if its not legible.....

Denise

5 pages

COLLEGES AND UNIVERSITIES RATE AGREEMENT

EIN #: 1720702000A1

DATE: July 31, 1996

INSTITUTION:
University of New Orleans

FILING REF.: The preceding Agreement was dated September 1, 1993

New Orleans LA 70148-

The rates approved in this agreement are for use on grants, contracts and other agreements with the Federal Government, subject to the conditions in Section III.

SECTION I: INDIRECT COST RATES*

RATE TYPES: FIXED FINAL PROV.(PROVISIONAL) PRED.(PREDETERMINED)

TYPE	EFFECTIVE PERIOD FROM	TO	RATE(%)	LOCATIONS	APPLICABLE TO
PRED.	07/01/96	06/30/99	42.0	On Campus	Research
PRED.	07/01/96	06/30/99	26.0	Off Campus	Research
PRED.	07/01/96	06/30/99	59.0	On Campus	Instruction
PRED.	07/01/96	06/30/99	39.0	Off Campus	Instruction
PROV.	07/01/96	UNTIL AMENDED	Use same rates and conditions as those cited for fiscal year ending June 30, 1999.		

*BASE:
Total direct costs excluding equipment, capital expenditures charges for patient care and tuition remission, rental costs, scholarships, and fellowships as well as the portion of each subgrant and subcontract in excess of $25,000.

INSTITUTION:
University of New Orleans

AGREEMENT DATE: July 31, 1996

SECTION II: SPECIAL REMARKS

TREATMENT OF FRINGE BENEFITS:
The fringe benefits are charged using a rate(s). Over/under recoveries from actual costs are adjusted in current or future periods. The directly claimed fringe benefits are listed below.

TREATMENT OF PAID ABSENCES:
Vacation, holiday, sick leave pay and other paid absences are included in salaries and wages and are claimed on grants, contracts and other agreements as part of the normal cost for salaries and wages. Separate claims for the costs of these paid absences are not made.

FRINGE BENEFITS:

FICA	Retirement
Life Insurance	TIAA/CREF
Worker's Compensation	Unemployment Insurance
Health Insurance	Termination Pay
Sabbatical Leave	Employees Education Privilege
Medicare Employees Match	LSU Money Purchase Plan

ORGANIZATION:
University of New Orleans

AGREEMENT DATE: July 31, 1996

SECTION III: GENERAL

A. LIMITATIONS:
The rates in this Agreement are subject to any statutory or administrative limitations and apply to a given grant, contract or other agreement only to the extent that funds are available. Acceptance of the rates is subject to the following conditions: (1) Only costs incurred by the organization were included in its indirect cost pool as finally accepted: such costs are legal obligations of the organization and are allowable under the governing cost principles; (2) The same costs that have been treated as indirect costs are not claimed as direct costs; (3) Similar types of costs have been accorded consistent accounting treatment; and (4) The information provided by the organization which was used to establish the rates is not later found to be materially incomplete or inaccurate by the Federal Government. In such situations the rate(s) would be subject to renegotiation at the discretion of the Federal Government.

B. ACCOUNTING CHANGES:
This Agreement is based on the accounting system purported by the organization to be in effect during the Agreement period. Changes to the method of accounting for costs which affect the amount of reimbursement resulting from the use of this Agreement require prior approval of the authorized representative of the cognizant agency. Such changes include, but are not limited to, changes in the charging of a particular type of cost from indirect to direct. Failure to obtain approval may result in cost disallowances.

C. FIXED RATES:
If a fixed rate is in this Agreement, it is based on an estimate of the costs for the period covered by the rate. When the actual costs for this period are determined, an adjustment will be made to a rate of a future year(s) to compensate for the difference between the costs used to establish the fixed rate and actual costs.

D. USE BY OTHER FEDERAL AGENCIES:
The rates in this Agreement were approved in accordance with the authority in Office of Management and Budget Circular A-21 Circular, and should be applied to grants, contracts and other agreements covered by this Circular, subject to any limitations in above. The organization may provide copies of the Agreement to other Federal Agencies to give them early notification of the Agreement.

E. OTHER:
The rates in this Agreement were approved in accordance with the cost principles promulgated by the Department of Health and Human Services, and should be applied to the grants, contracts and other agreements covered by these regulations subject to any limitations in A above. The hospital may provide copies of the Agreement to other Federal Agencies to give them early notification of the Agreement.

BY THE INSTITUTION: Board of Supervisors of Louisiana State University and Agricultural and Mechanical College
University of New Orleans
(INSTITUTION)

(SIGNATURE)

PATRICK M. GIBBS
(NAME)

Vice Chancellor for Business Affairs
(TITLE)

September 5, 1996
(DATE)

BY THE COGNIZANT AGENCY
ON BEHALF OF THE FEDERAL GOVERNMENT:

DEPARTMENT OF HEALTH AND HUMAN SERVICES
(AGENCY)

(SIGNATURE)

Merle M. Schmidt
(NAME)

DIRECTOR, DIVISION OF COST ALLOCATION
(TITLE)

July 31, 1996
(DATE) 0013

HHS REPRESENTATIVE: J. Allen Keaton
Telephone: (214) 767-3261 X410

I -019356

I-019356

COMPONENTS OF PUBLISHED INDIRECT COST RATES

INSTITUTION: UNIVERSITY OF NEW ORLEANS

FY covered by rate: 1997 - 1999

Rate Component	RESEARCH ON	RESEARCH OFF
1. Use allowance	5.5%	
2. O&M	9.9%	
3. G&A	26.0%	26.0%
4. DA		
5. Library	.6%	
Published Rates	42.0%	26.0%

Name Patrick M Gibbs
PATRICK M. GIBBS

Title Vice Chancellor for Business Affairs

Date September 5, 1996

OFFICE OF THE DEAN OF RESEARCH

OREGON STATE UNIVERSITY
312 Kerr Administration Building · Corvallis, Oregon · 97331-2140
541-737-3437 · FAX 541-737-3093 · INTERNET scanlanr@comail.orst.edu

November 10, 1997

MEMORANDUM

TO: President, Provost, Vice Provosts, Deans, Directors, Department Heads, Principal Investigators, and Department Accountants

FROM: Richard A. Scanlan, Dean of Research
Karen S. Steele, Assistant Director, Business Affairs

SUBJECT: Update on Information for Proposal Preparation

Fringe benefit (OPE) rates:

We recommend that PI's and departments use the academic and classified OPE rates on the attached table for proposal budgets. The OPE rates in the table were calculated to cover maximum OPE and cash back costs that are likely to be incurred at a given salary level through June 30, 1998. The rates for years beyond June 30, 1998 are based on our best estimate as to what will be forthcoming from future legislative sessions; they are based on the opinion held by many that costs for medical and dental care will continue to increase in the foreseeable future.

As in the past, you can use actual OPE rates if the history of a particular person indicates that a different rate is justified. However, you should be aware that in all likelihood a person's OPE rates will increase in the future. Furthermore, if that person were to leave, you may have to replace the person with someone with higher OPE and cash back costs.

Inflation:

We believe that a 4% increase for all direct cost budget categories not covered by the tables that follow would be a reasonable inflation rate for each future budget year. We suggest use of 4% unless the agency guidelines specify otherwise.

Equipment Definition:

Equipment is now defined as tangible personal property with a unit value of $5,000 or more and a life expectancy of more than one year. Please use this threshold unless the agency guidelines specifically state that its threshold is lower.

Update on Information for Research Proposal Preparation
November 10, 1997

OREGON STATE UNIVERSITY
OPE plus Cash Back Rate For Use on Grant Proposals
ACADEMIC AND CLASSIFIED (9- and 12-month 0.50 FTE or greater)*

Total Monthly Salary from All Accounts	FISCAL YEAR OF PROPOSAL START DATE					
	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
$6,000 -	32%	34%	34%	34%	35%	35%
$4,200 - $5,999	35%	37%	38%	38%	39%	40%
$3,300 - $4,199	39%	41%	41%	42%	43%	44%
$2,700 - $3,299	42%	44%	45%	46%	47%	48%
$2,300 - $2,699	45%	47%	48%	50%	51%	52%
$2,000 - $2,299	49%	51%	52%	53%	55%	56%
$1,700 - $1,999	53%	55%	57%	58%	60%	62%
$1,400 - $1,699	60%	62%	63%	65%	67%	69%
$1,100 - $1,399	70%	72%	74%	76%	79%	81%
- $1,099	80%	82%	85%	88%	91%	94%

*Use the OPE rate for the salary and year specified in the table (i.e., a person whose total monthly salary from all sources is $2,500 would use the OPE rate of 45% for the first year of a proposal with a start date within FY 97-98. If that person's salary increased in year 2 to $2,600, the OPE rate of 47% would be used. Similarly, if the person's salary increased to $2,700 in year 3, the OPE rate of 45% would be used.)

Exceptions to the above table are:

Classification	Description	Benefits	Retirement	OPE
Academic	Less than 90 days regardless of FTE	No	No (unless already on PERS)	10%
	90 days or more, less than .50 FTE per month	No	Maybe	25%
Classified	Temporary	No	Maybe	25%
	Permanent, less than .50 FTE per month	No	Maybe	25%
1040-hour appt.	Less than 1 term	No	No	10%
	Less than .50 FTE per month	No	No	10%
	At least 1 term, .50 FTE or above per month	Yes	No	30%
COAS sea pay		No	No	10%
Extension	Academic			32%
Grad students on appt.	GRA's and GTA's			1%
Undergrad or grad students	Hourly			5%

Update on Information for Research Proposal Preparation
November 10, 1997

Indirect Costs:
Indirect cost rates have been negotiated with the Department of Health and Human Services for July 1, 1995 through June 30, 2000 in an agreement dated June 21, 1995. Please use the indirect cost rates indicated below.

Item No.	Type of Proposal	FISCAL YEAR		
		1997-98	1998-99	1999-2000 and Beyond
1.	On-campus Research	42.5%	42.5%	43.0%
2.	Off-campus Research	26.0%	26.0%	26.0%
3.	On-campus Instruction	43.0%	43.0%	43.0%
4.	Off-campus Instruction	26.0%	26.0%	26.0%
5.	On-campus Extension	21.5%	21.5%	21.5%
6.	Off-campus Extension	20.3%	20.3%	20.3%
7.	State of Oregon Agency	26.0%	26.0%	26.0%
8.	Vessel Operations	30.0%	30.0%	30.0%

Items 1-7 are determined on a "Modified Total Direct Costs" (MTDC) base. This MTDC base includes all direct costs less expenditures for equipment (see definition on first page of memo), graduate tuition, building and land rental, capitalized building improvements, and the portion of each subcontract in excess of $25,000 (indirect cost on the first $25,000 of each subcontract is calculated using the rate negotiated on the grant or contract). The vessel rate (item 8) is based on gross salaries and wages except for overtime premiums.

If the proposed sponsor requires a rate other than those indicated in the above table, apply the sponsor's rate to total direct costs, unless otherwise stipulated in the sponsor guidelines, and attach a copy of the sponsor's guidelines to the proposal check-off sheet.

The off-campus rate is applicable to projects conducted in facilities non-owned or non-controlled by OSU (including the NOAA facility at the HMSC) and must be for a period of at least 90 consecutive days or the life-term of the contract, whichever is shorter. The Hatfield Marine Science Center does not qualify for the off-campus rate, but the Branch Agricultural Experiment Stations do qualify. Sometimes it may be appropriate to split the budget into two separate budgets and work plans to identify on- and off-campus costs. Upon receipt of an award, separate funds will be set up for on- and off-campus portions. The on-campus rate should be used in cases when OSU is required to pay rent or utilities and we are not permitted by the agency to charge these costs directly to the contract.

To calculate indirect costs for budget years which do not begin on July 1, apply the rate in effect at the beginning of your proposed year to the entire year. For example, if your on-campus research budget begins on April 1, 1998 and runs for three years, use 42.5% for the first 12-month period, 42.5% for the second 12-month period, and 43.0% for the third 12-month period.

Update on Information for Research Proposal Preparation
November 10, 1997

Graduate Tuition:

The following estimated rates presume nine credit hours for summer session and full-time status (9-16 hours) during the academic year. For the summer session, add the additional amount shown for each hour over nine hours. Anything over 16 hours in the summer session must be paid by the student. **Tuition remission not allowed by an agency is a cost-share expense that should be identified in the budget and on the check-off sheet.**

Term	Tuition Cost per Term		Summer Session Additional Charge for Each Hour Over 9 Hours Per Term
	Academic Year	Summer Session	
1997-98 Academic Year	$1,732		
1998 Summer Session		$1,110	$120
1998-99 Academic Year	$1,819		
1999 Summer Session		$1,166	$126
1999-00 Academic Year	$1,910		
2000 Summer Session		$1,224	$132
2000-01 Academic Year	$2,006		
2001 Summer Session		$1,285	$139
2001-02 Academic Year	$2,106		
2002 Summer Session		$1,349	$146
2002-03 Academic Year	$2,211		
2003 Summer Session		$1,416	$153
2003-04 Academic Year	$2,322		
2004 Summer Session		$1,487	$161

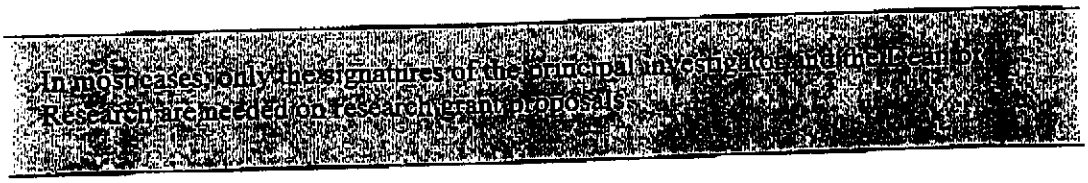
Note: Grants pay for GRA and GTA tuition only, not including fees. The student must pay her/his own fees and thesis microfilming charges. (Tuition for both resident and non-resident GRA's/GTA's is charged at the resident tuition rate.)

Additional Information:

Animal Welfare Policy Assurance No.	A-3229-01
DUNS No.	053599908
Employer ID No. & Entity No. (IRS No.)	93-6001786
Human Subjects Assurance No.	M-1099-01

Update on Information for Research Proposal Preparation
November 10, 1997

Signatures:



The name and title for the Research Office signature block (i.e. institutional representative, responsible authorized official) is:

Wilson C. "Toby" Hayes
Vice Provost for Research
(541) 737-3437
FAX (541) 737-3093
E-mail: wilson.hayes@orst.edu

If a signature by a contract officer or negotiator is required by the sponsor, use:

Clem LaCava
Assistant Contract Manager
(541) 737-2373
FAX (541) 737-2069
E-mail: clem.lacava@orst.edu

If the name and/or signature of the financial officer or Business Affairs official is required (e.g., NIH/PHS grants), use:

Karen Steele
Asst. Director of Business Affairs
Oregon State University
P.O. Box 1086
Corvallis, OR 97339-1086
(541) 737-2294
FAX (541) 737-2069
E-mail: karen.steele@orst.edu

If you have further questions, please call:

Pre-Award:
General budget questions: Diana Evans 7-0668 or Laura Lincoln, 7-8008.
Funding source information or human subjects research: Mary Nunn 7-0670

Post-Award:
Research Accounting: 7-4711

Contracts:
Asst. Contract Administrator: Clem LaCava, 7-2373

bh
p:ratemo97.doc
(page 5 updated 9/2/98)

Brian A. Bergamaschi, Ph.D.
United States Geological Survey
Water Resources Division
California State University, Placer Hall, 6000 J Street
Sacramento, California 95819-6129
(916) 278-3053 Fax (916) 278-3071 bbergams@usgs.gov

Memorandum

Date: March 30, 1999

Subject: **Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 1. Compositional Characteristics.**

Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Bay Conservation and Development Commission

30 Van Ness Aveaue, Room 2011

San Francisco, CA 94102

Dear Sir or Madam:

This memo is to inform you that we will be submitting the two proposals identified in the subject line above in response to the CALFED Bay-Delta Program February 1999 Proposal Solicitation. CALFED requires that we provide notification to counties that may be affected by proposed work prior to submission.
Rivers, wetlands, and agricultural operations supply organic material to the Sacramento-San Joaquin Delta and San Francisco Estuary, providing essential nutritive material to the food web and thus an important ecosystem benefit. Unfortunately, organic material in Delta drinking source waters increases the difficulty of treating those waters, and may result in the formation of carcinogenic disinfection byproducts (DBPs) regulated by US EPA.

These activities outlined under these proposals will supply information to CALFED restoration managers. As CALFED proceeds with ecosystem restoration activities, it is desired that Delta restorations be implemented to provide sources of beneficial organic material while minimizing sources of organic material adversely impacting drinking water treatment. However, little quantitative information is available regarding the amount or quality of organic material released from different types of wetlands (or even agricultural sources) and its affect on either the Delta food web or on drinking water treatment.

Brian A. Bergamaschi, Ph.D.
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Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Delta Protection Commission

14215 River Road

P.O. Box 530

Walnut Grove, CA 95690

Dear Sir or Madam:

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Memorandum

Date: April 14, 1999

Subject: **Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 1. Compositional Characteristics.**

Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Community Development Planning Supervisor

1810 E. Hazelton Avenue

Stockton, California

Dear Sir or Madam:

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Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: County Board of Supervisors

222 E. Weber Avenue, Room 701

Stockton, California

Dear Sir or Madam:

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Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Yolo County Planning Supervisor

292 W. Beamer Street

Woodland, CA

Dear Sir or Madam:

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Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Yolo County Supervisor

625 Court Street

Woodland, CA

Dear Sir or Madam:

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Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Contra Costa County Supervisor

651 Pine Street, Room 108A

Martinez, CA 94553

Dear Sir or Madam:

This memo is to inform you that we will be submitting the two proposals identified in the subject line above in response to the CALFED Bay-Delta Program February 1999 Proposal Solicitation. CALFED requires that we provide notification to counties that may be affected by proposed work prior to submission.

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Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Contra Costa Planning Supervisor

651 Pine Street, No. Wing, Fourth Floor

Martinez, CA 94553

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To: Sacramento County Planning Supervisor

700 H Street

Sacramento, CA 95814

Dear Sir or Madam:

This memo is to inform you that we will be submitting the two proposals identified in the subject line above in response to the CALFED Bay-Delta Program February 1999 Proposal Solicitation. CALFED requires that we provide notification to counties that may be affected by proposed work prior to submission.

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Memorandum

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Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Sacramento County Supervisor

700 H Street

Sacramento, CA 95814

Dear Sir or Madam:

This memo is to inform you that we will be submitting the two proposals identified in the subject line above in response to the CALFED Bay-Delta Program February 1999 Proposal Solicitation. CALFED requires that we provide notification to counties that may be affected by proposed work prior to submission.

Rivers, wetlands, and agricultural operations supply organic material to the Sacramento-San Joaquin Delta and San Francisco Estuary, providing essential nutritive material to the food web and thus an important ecosystem benefit. Unfortunately, organic material in Delta drinking source waters increases the difficulty of treating those waters, and may result in the formation of carcinogenic disinfection byproducts (DBPs) regulated by US EPA.

These activities outlined under these proposals will supply information to CALFED restoration managers. As CALFED proceeds with ecosystem restoration activities, it is desired that Delta restorations be implemented to provide sources of beneficial organic material while minimizing sources of organic material adversely impacting drinking water treatment. However, little quantitative information is available regarding the amount or quality of organic material released from different types of wetlands (or even agricultural sources) and its affect on either the Delta food web or on drinking water treatment.

Brian A. Bergamaschi, Ph.D.
United States Geological Survey
Water Resources Division
California State University, Placer Hall, 6000 J Street
Sacramento, California 95819-6129
(916) 278-3053 Fax (916) 278-3071 bbergama@usgs.gov

Memorandum

Date: March 30, 1999

Subject: **Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 1. Compositional Characteristics.**

Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb, part 2. Fluxes and Loads

To: Solano County Supervisor

580 Texas Street

Fairfield, CA 94533

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